

WHAT IS CLAIMED IS:

1 1. A hydraulic control system for a belt-drive continuously
2 variable transmission (CVT) of a vehicle, the CVT including
3 a belt, the hydraulic control system comprising:
4 an oil pump operative to produce an oil pressure and an
5 oil flow amount which are supplied to the CVT;
6 a pressure regulator valve operative to regulate the oil
7 pressure produced by the oil pump;
8 a belt lubricating oil supply passage for supplying oil
9 to the belt on a downstream side of the pressure regulator
10 valve;
11 engine operating condition detecting means for detecting
12 an engine operating condition and generating a signal
13 indicative of the engine operating condition detected; and
14 a controller for controlling the oil flow amount based
15 on the signal, the controller being programmed to:
16 calculate a CVT input torque based on the signal;
17 calculate a required belt lubricating oil flow amount to
18 be supplied to the belt on the basis of the signal and the
19 CVT input torque;
20 determine a minimum speed of the oil pump based on the
21 required belt lubricating oil flow amount; and
22 control the oil pump at the minimum speed.

1 2. The hydraulic control system as claimed in claim 1,
2 wherein the engine operating condition detecting means
3 comprises an oil temperature sensor operative to detect a
4 temperature of the oil in the CVT and generate an oil
5 temperature signal indicative of the oil temperature
6 detected.

1 3. The hydraulic control system as claimed in claim 1,
2 wherein the engine operating condition detecting means

3 comprises a throttle position sensor operative to detect a
4 throttle opening degree and generate a throttle opening
5 degree signal indicative of the throttle opening degree
6 detected.

1 4. The hydraulic control system as claimed in claim 2,
2 wherein the CVT includes a primary pulley, the hydraulic
3 control system further comprising primary pulley speed
4 detecting means for detecting rotational speed of the
5 primary pulley and generating a primary pulley speed signal
6 indicative of the rotational speed detected, the controller
7 receiving the primary pulley speed signal, the controller
8 being programmed to calculate the required belt lubricating
9 oil flow amount based on at least one of the CVT input
10 torque and the primary pulley speed signal when the oil
11 temperature is not less than a predetermined value.

1 5. The hydraulic control system as claimed in claim 4,
2 wherein the CVT includes a secondary pulley, the hydraulic
3 control system further comprising secondary pulley speed
4 detecting means for detecting rotational speed of the
5 secondary pulley and generating a secondary pulley speed
6 signal indicative of the rotational speed detected, the
7 controller receiving the secondary pulley speed signal, the
8 controller being programmed to:

9 calculate a pulley speed ratio between the rotational
10 speed of the primary pulley and the rotational speed of the
11 secondary pulley; and

12 calculate the required belt lubricating oil flow amount
13 based on at least one of the CVT input torque, the primary
14 pulley speed signal and the pulley speed ratio when the oil
15 temperature is not less than a predetermined value.

1 6. The hydraulic control system as claimed in claim 2,
2 further comprising an oil cooler disposed on a downstream
3 side of the pressure regulator valve, a lubricating oil
4 supply path for supplying the oil to lubrication parts in
5 the CVT, the lubricating oil supply path being disposed on a
6 downstream side of the oil cooler and including the belt
7 lubricating oil supply passage, and line pressure detecting
8 means for detecting a line pressure between the oil pump and
9 the pressure regulator valve and generating a line pressure
10 signal indicative of the line pressure detected, the
11 controller receiving the line pressure signal, the
12 controller being programmed to:

13 calculate a required cooler oil flow amount to be
14 supplied to the oil cooler from the required belt
15 lubricating oil flow amount on the basis of a predetermined
16 oil distribution ratio of an oil flow amount to be supplied
17 to the belt lubricating oil supply passage to an oil flow
18 amount to be supplied to the lubricating oil supply path;

19 calculate a cooler input pressure to be supplied to the
20 oil cooler on the basis of the required cooler oil flow
21 amount; and

22 determine the minimum speed of the oil pump based on the
23 cooler input pressure, the oil temperature signal and the
24 line pressure signal.

1 7. The hydraulic control system as claimed in claim 5,
2 wherein the CVT has a manual transmission mode allowing to
3 manually change the pulley speed ratio, the hydraulic
4 control system further comprising transmission mode
5 detecting means for detecting that the CVT is in the manual
6 transmission mode and generating a manual mode signal
7 indicative of the CVT in the manual transmission mode, the

8 controller being programmed, in response to the manual mode
9 signal, to clear the minimum speed of the oil pump.

1 8. The hydraulic control system as claimed in claim 5,
2 wherein the CVT has a manual transmission mode allowing to
3 manually change the pulley speed ratio and an automatic
4 transmission mode allowing to automatically change the
5 pulley speed ratio, the hydraulic control system further
6 comprising transmission mode detecting means for detecting
7 whether the CVT is in the manual transmission mode or in the
8 automatic transmission mode and generating a manual mode
9 signal indicative of the CVT in the manual transmission mode
10 and an automatic mode signal indicative of the CVT in the
11 automatic transmission mode, the controller being programmed,
12 in response to the manual mode signal, to set the minimum
13 speed of the oil pump larger than in the automatic
14 transmission mode.

1 9. The hydraulic control system as claimed in claim 1,
2 wherein the vehicle includes an anti-lock brake system (ABS)
3 actuator operative to control a braking pressure, an ABS
4 control unit for generating an ABS control signal to the ABS
5 actuator, and an ABS control sensor operative to detect the
6 ABS control signal and generate an ABS control ON signal
7 indicative of ABS control being conducted, the controller
8 being programmed, in response to the ABS control ON signal,
9 to clear the minimum speed of the oil pump.

1 10. The hydraulic control system as claimed in claim 6,
2 wherein the belt lubricating oil supply passage comprises a
3 belt lubricating nozzle for injecting the oil to the belt,
4 the lubricating oil supply path comprising a gear

5 lubricating nozzle for injecting the oil to a differential
6 gear.

1 11. A method for controlling a belt-drive continuously
2 variable transmission (CVT) of a vehicle, the CVT including
3 a belt, the vehicle including an oil pump operative to
4 produce an oil pressure and an oil flow amount which are
5 supplied to the CVT, a pressure regulator valve operative to
6 regulate the oil pressure produced by the oil pump, and a
7 belt lubricating oil supply passage for supplying oil to the
8 belt on a downstream side of the pressure regulator valve,
9 the method comprising:

10 generating an engine operating condition signal
11 indicative of an engine operating condition;

12 calculating a CVT input torque based on the engine
13 operating condition signal;

14 calculating a required belt lubricating oil flow amount
15 to be supplied to the belt on the basis of the engine
16 operating condition signal and the CVT input torque;

17 determining a minimum speed of the oil pump based on the
18 required belt lubricating oil flow amount; and
19 controlling the oil pump at the minimum speed.

1 12. The method as claimed in claim 11, wherein the engine
2 operating condition signal comprises an oil temperature
3 signal indicative of a temperature of the oil in the CVT,
4 the required belt lubricating oil flow amount being
5 calculated based on the oil temperature signal.

1 13. The method as claimed in claim 11, wherein the engine
2 operating condition signal comprises a throttle opening
3 degree signal, the CVT input torque being calculated based
4 on the throttle opening degree signal.

1 14. The method as claimed in claim 12, wherein the CVT
2 includes a primary pulley, the method further comprising
3 generating a primary pulley speed signal indicative of a
4 rotational speed of the primary pulley, and calculating the
5 required belt lubricating oil flow amount based on at least
6 one of the CVT input torque and the primary pulley speed
7 signal when the oil temperature is not less than a
8 predetermined value.

1 15. The method as claimed in claim 14, wherein the CVT
2 includes a secondary pulley, the method further comprising:
3 generating a secondary pulley speed signal indicative of
4 a rotational speed of the secondary pulley;
5 calculating a pulley speed ratio between the rotational
6 speed of the primary pulley and the rotational speed of the
7 secondary pulley; and
8 calculating the required belt lubricating oil flow
9 amount based on at least one of the CVT input torque, the
10 primary pulley speed signal and the pulley speed ratio when
11 the oil temperature is not less than a predetermined value.

1 16. The method as claimed in claim 12, wherein the vehicle
2 includes an oil cooler disposed on the downstream side of
3 the pressure regulator valve and a lubricating oil supply
4 path for supplying the oil to lubrication parts in the CVT,
5 the lubricating oil supply path being disposed on a
6 downstream side of the oil cooler and including the belt
7 lubricating oil supply passage, the method further
8 comprising:
9 generating a line pressure signal indicative of a line
10 pressure between the oil pump and the pressure regulator
11 valve;

12 calculating a required cooler oil flow amount to be
13 supplied to the oil cooler from the required belt
14 lubricating oil flow amount on the basis of a predetermined
15 oil distribution ratio of an oil flow amount to be supplied
16 to the belt lubricating oil supply passage to an oil flow
17 amount to be supplied to the lubricating oil supply path;

18 calculating a cooler input pressure to be supplied to
19 the oil cooler on the basis of the required cooler oil flow
20 amount; and

21 determining the minimum speed of the oil pump based on
22 the cooler input pressure, the oil temperature signal and
23 the line pressure signal.

1 17. The method as claimed in claim 15, wherein the CVT has
2 a manual transmission mode allowing to manually change the
3 pulley speed ratio, the method further comprising:

4 generating a manual mode signal indicative of the CVT in
5 the manual transmission mode; and

6 clearing, in response to the manual mode signal, the
7 minimum speed of the oil pump.

1 18. The method as claimed in claim 15, wherein the CVT has
2 a manual transmission mode allowing to manually change the
3 pulley speed ratio and an automatic transmission mode
4 allowing to automatically change the pulley speed ratio, the
5 method further comprising:

6 generating a manual mode signal indicative of the CVT in
7 the manual transmission mode and an automatic mode signal
8 indicative of the CVT in the automatic transmission mode;
9 and

10 setting, in response to the manual mode signal, the
11 minimum speed of the oil pump larger than in the automatic
12 transmission mode.

1 19. The method as claimed in claim 11, wherein the vehicle
2 includes an anti-lock brake system (ABS) actuator operative
3 to control a braking pressure and an ABS control unit for
4 generating an ABS control signal to the ABS actuator, the
5 method further comprising:

6 generating an ABS control ON signal indicative of ABS
7 control being conducted; and

8 in response to the ABS control ON signal, clearing the
9 minimum speed of the oil pump.

1 20. The method as claimed in claim 16, wherein the belt
2 lubricating oil supply passage comprises a belt lubricating
3 nozzle for injecting the oil to the belt, the lubricating
4 oil supply path comprising a gear lubricating nozzle for
5 injecting the oil to a differential gear.